Appendix B

Abstracts

Aircraft & Propulsion Volume Abstract

The Aircraft and Propulsion Panel was chartered to identify and recommend aircraft and propulsion technologies and concepts that have potential to favorably impact the ability of the USAF to accomplish its mission in the future.

The panel held five fact-finding meetings with DoD scientific agencies. Six attributes are identified as critical to future USAF air vehicles: affordability, lethality, flexibility, survivability, speed and range. In conjunction with the applications panels and considering these critical attributes, seven air vehicle concepts are identified to fulfill future USAF requirements: modular vehicles, uninhabited aircraft, hypersonic vehicles, future attack aircraft, large transport aircraft, special operations aircraft, and long endurance aircraft.

The key technologies required to develop these vehicle concepts have been identified and evaluated as to criticality and readiness. An overall assessment of enabling aircraft and propulsion technologies is provided along with a discussion of important infrastructure concerns including test facilities and USAF laboratory structure.

Recommendations are made for the USAF to pursue air vehicle technologies that are required to support future missions, to retain and modernize its ground test facilities and to pursue experimental and flight research programs. These actions will protect the technology base and air vehicle development capability necessary to provide air-vehicle systems superior to those of any adversary.

Dr. Richard G. Bradley, Jr.
Chair, Aircraft & Propulsion Panel
15 December 1995

Panel Membership

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Dr. Douglas L. Dwoyer
Dr. William H. Heiser
Mr. William J. King
Dr. James D. Lang
Dr. James G. Mitchell
Dr. G. Keith Richey
Prof. Terrence A. Weisshaar
Capt Christopher N. Berg
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Attack Volume Abstract

Shaping the Air Force to meet the needs of the future is a daunting undertaking. We chose a fundamental and operationally oriented approach for revealing and defining the types of operational capabilities most relevant for any future. Stated at the most generic level, the purpose of military power is to protect the nation to the extent possible within the constraints imposed. *We seek those operational capabilities that allow us to conduct any missions, meet any contingency, and win any war.*

The role of military power is to control (dictate and enforce) the operations of all types of enemy forces. We *define* in detail the enemy operations we wish to control and the *tasks* required to achieve those objectives, *framing operational capabilities* down to the tactical level. These *tasks are* by definition *enduring, important and there is considerable opportunity and need for improvement*. Finally, we *define* the *operational concepts* to accomplish the tasks. These *concepts establish* the needed *functional capabilities.* We then, *define the systems and capabilities required to provide* these *functional capabilities*—for three time periods: 1995, 2000-2010, and 2005-2025.

Mrs. Natalie W. Crawford
Chair, Attack Panel
15 December 1995

Panel Membership

Mrs. Natalie W. Crawford, Chair
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Maj Gen Gerald J. Carey, USAF (Ret)
Mr. Ramon L. Chase
Mr. Jerauld R. Gentry
Mr. Dennis L. Holeman
Lt Gen Glenn A. Kent (Ret)
Mr. Sherman N. Mullin
Maj Steve W. Martin
Capt Donna J. Williams

Maj Michael K. Reagan

Directed Energy Volume Abstract

Directed energy weapons, both lasers and microwaves, will have widespread application over the next few decades. A substantial technical data base now allows confident anticipation of weapon applications. Initial airborne weapons to provide boost-phase defense against ballistic missiles and defense of aircraft against missiles will lead the way to space-based, or space-relayed, weapons. Global presence with weapons capable of destroying or disabling anything that flies as well as most unarmored ground targets will drive a new warfare paradigm.

This volume discusses directed energy applications that are most probable as well as most important in three time periods: 10, 20, and 30 years in the future. The technologies that should be supported to enable these applications are discussed leading to several conclusions and recommendations. Our intent is that these recommendations are sufficiently detailed to provide rapid definition of technology thrusts in laboratory programs. Reference is also made to a number of classified annexes that cannot be discussed herein.

Maj Gen Donald L. Lamberson (Ret)
Chair, Directed Energy Panel
15 December 1995

Panel Membership

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Dr. Gene H. McCall
Mr. John M. McMahon
Dr. Walter R. Sooy
Mr. Darrell E. Spreen
Lt Col Mike L. Crawford

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Lt Col David G. Hincy

Human Systems/Biotechnology Volume Abstract

All Air Force systems must be human-centered, from design to operations. People are central to all Air Force activities. No matter how the battlefield of a particular future conflict evolves, and no matter what mix of power is used, there will always be a human in every loop, to exercise command and control.

Human-centered design, development, manufacturing, and fielding provide the only way to ensure maximized human performance, especially for the "most-certain-to-come" capability of fusion of the human/machine interface into one being. Air Force goals of better human information-processing and decision making, and better understanding of mental processes such as reasoning and memory, are central to situational awareness of the future battlefield, and to winning.

Air Force investment in cognitive science and neurobiology now, at the Air Force Office of Scientific Research and the laboratories, must be protected at all cost. These sciences are enabling. The huge savings in training costs, up to 50%, the huge savings in logistics management through new human-centered visualization technology, and the saving of lives through neutralization of human fatigue in combat, all flow from these enabling sciences. They enable us to win in a world where everyone has pieces of our national technological array of capabilities.

Dr. Garrison Rapmund, MD
Chair, Human Systems/Biotechnology Panel
15 December 1995

Panel Membership

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Dr. Wallace T. Prophet
Dr. Adelia E. Ritchie
Dr. Henry L. Taylor
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Information Applications Volume Abstract

The US Air Force is a young service, and is about to experience its first paradigm shift. The expanded use of information systems will radically alter the tasks associated with putting energy on targets. In addition, early in the next century, warfare will take place within these same information systems.

Coupling new information systems with the global reach of the Air Force will form the basis for a potent new form of military aerospace power. Dealing with information warfare in a fundamental way will bring about a profound cultural shift in the Air Force. This shift will begin in earnest over the next decade, and may be wrenching for those imbued with the cultural heritage of manned aircraft.

To respond to these changes, the Air Force must expand its traditional role as the leading proponent of air and space power to include an equally important role in cyberspace. To the extent the Air Force can effectively unite aerospace power with information based power, it will remain a dominant factor in the defense of our nation. To help accomplish this goal, the Information Applications Panel monographs provide details of long term research and development for:

- Situation awareness
- Communications
- Battle planning and execution management
- Computer security
- Information warfare

Dr. Charles L. Morefield
Chair, Information Applications Panel
15 December 1995

Panel Membership

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Capt Dean F. Osgood

Information Technology Volume Abstract

The task of the Information Technology (IT) panel is to project the visible trends of the continuing revolution in information technology and, where projection fades at the horizon, to envision further progress. We have done this in two ways.

First, systematically we surveyed the areas of IT work. Examples are communications, computer system architectures, the interface between computers and people, software and the technologies for its development, the emergence of artificial intelligence software that emulates human-like thought processes, software that learns and adapts itself to user needs, technologies for crypto-secrecy and for assured access to systems and networks, and several more.

Second, we projected and envisioned specific achievements, stretching out over twenty years or more -- highlights of the information future. Some are evolutionary, "big wins" with high probability of being achieved. Others represent discontinuities; we do not know if they will arrive but if they do, their impact will be revolutionary. Still others represent technological, educational and organizational concerns for the future of the Air Force in the era of the information revolution.

Military needs no longer drive this revolution. The good news is often we can buy off-the-shelf hardware, software, and communications that are much better than, and very much cheaper than, what we can have custom-built for us. The Air Force is challenged to adapt to this new way of doing business, and to benefit from the best commercial technology can offer (just as our friends and enemies can). But some information technologies the Air Force needs will not emerge from the commercial marketplace. Our panel made judgments about what these will be as a set of recommendations for continued Air Force and DOD R&D funding priorities for information technology. Our panel also points out where the Air Force can benefit from starting to rethink right now how information technology can improve its weapon system design, acquisition, management, education and career development processes.

Dr. Edward A. Feigenbaum
Chair, Information Technology Panel
15 December 1995

Panel Membership

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Prof. John E. Hopcroft
Dr. Robert W. Lucky
Dr. Donald L. Nielson
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Materials Volume Abstract

Air Force battlefield superiority is maintained, to a significant extent, by the use of advanced materials that enable weapons and weapons platforms to accomplish specific aerospace missions. The driver for the introduction of new materials in the past has been improved performance, and performance will continue to be the driver in the future. We are now entering an age when these materials will be designed to have specific properties using advanced computational techniques at the atomic/molecular level. The Air Force must strive to maintain a leadership role in new materials science and technology, because it is unlikely that commercial suppliers could meet critical Air Force needs in the absence of large commercial markets. The Air Force must also develop pathways for the more rapid introduction of new material into new and existing flight systems; these pathways must enable the introduction of new materials in a rational manner even if significant initial risk exists. Finally, in light of tightening environmental regulations, the Air Force should move to life cycle costing to ensure that the cost of disposal or recycling of specific materials is adequately covered and will not become a burden on future Air Force budgets.

Prof. Digby D. Macdonald
Chair, Materials Panel
15 December 1995

Panel Membership

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Mobility Volume Abstract

The political changes around the world result in US forces being primarily based in the US. Consequently, heavier demand falls on the Mobility Command to provide true global reach and global power. After reviewing the needs associated with this requirement, the Mobility Panel selected five areas embodying revolutionary technology to improve mobility.

1. Information Dominance -- world-wide communications, information on demand in the cockpit, and intransit visibility of cargo.

2. Global Range Transport -- new airplane weighing about 900,000 pounds, carrying 150,000 pounds cargo for 12,000 nautical miles unrefueled.

3. Precision/Large Scale Airdrop -- 100 foot accuracy, integral wind sensing, family of airdrop systems.

4. Directed Energy Self Defense Weapon -- a kilojoule laser system to defeat ground-to-air and air-to-air missiles.

5. Virtual Reality Applications -- use of holographic displays, synthetic sensory environment, communication networks, etc. for mission training.

The key technologies needed to attain these capabilities are: 1) accurate, timely, and dependable information through computer controlled satellite and fiber optic networks, 2) high temperature materials for advanced turbofan engines, 3) low cost composites for airframes, 4) airborne laser, 5) airborne wind-measurement sensors, and 6) synthetic environment generation.

Mr. Robert J. Patton
Chair, Mobility Panel
15 December 1995

Panel Membership

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Mr. Andrew W. Bennett
Mr. Richard J. Busch
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Dr. John C. Houbolt
Mr. John M. Ledden
Mr. Henry A. Shomber
Mr. Harry Sutcliffe
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Munitions Volume Abstract

The Munitions Panel identified several high payoff munitions concepts that address recognized and future US defense needs. The weapon concepts are achievable within the next 10-30 years and will significantly enhance the warfighting capabilities of the US Air Force. In general, we focused on smaller, lighter, agile, more lethal, and more affordable weapons that respond to a spectrum of Air Force missions and the target strike capability of delivery platforms. Some of the enabling technologies for these weapon concepts exist today, others are just ahead, and certain key ones await fundamental breakthroughs in technologies. Combined with innovative and creative approaches to weaponry design, all offer significant enhancements to Air Force warfighting.

The following recommendations will effectively exploit and implement the high pay off munition concepts identified to address projected US defense concerns: an Airborne Interceptor Missile to counter theater ballistic missiles; an RF Attack Cruise Missile to prevent enemy electronic operations; a Self Protect Missile for aircraft self defense; Autonomous Miniature Munitions to stop invading armies; an Airborne Interceptor Missile to counter low observable cruise missiles; Hard Target Munitions and Robotic Micro Munitions to attack deeply buried hard targets; and a Hypersonic Missile to attack quickly.

As an example of the importance of these concepts, we highlight autonomous miniature precision munitions which are small, self piloting, highly lethal munitions. These are capable of halting advancing armies because they are capable of autonomous target acquisition and classification. They incorporate adaptable warheads appropriate for a wide range of soft and hard targets. The autonomous precise miniature munitions offer a powerful way to defeat enemy forces rapidly. The conventional strategic bomber and tactical aircraft force could deliver over 20,000 self targeting munitions in one strategic tactical raid -- shutting down enemy forward air defenses, halting his armored assault, suppressing surface-to-surface missile operations, and impeding second echelon forces.

Additionally, key enabling technologies and capabilities are identified with specific science and technology approaches. Further, we have specified several munitions technology integrating concepts, and finally, we cite next step actions to implement the most important munition concepts.

Mr. Milton Finger
Chair, Munitions Panel
15 December 1995

Panel Membership

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Mr. Jesse T. McMahan
Dr. Robert W. Selden
Dr. Michael Shatz
Mr. Theodore W. Wong

Dr. Joe C. Foster
Dr. Paul L. Jacobs
Dr. Sam C. Lambert
Lt Col Edward V. Davis
Lt Col Kurt J. Klingenberger
Lt Col David G. Hincy

Sensors Volume Abstract

"To Know More and to Know It Sooner"

Sensors are essential elements of virtually every Air Force weapon and support system. The hardware and software associated with sensing functions are generally major, and sometimes predominant, contributors to the performance, reliability, supportability, and cost of such systems. They can exploit the full electromagnetic spectrum by intercepting reflected or naturally occurring electromagnetic radiation, detect various forms of mechanical energy (e.g., seismic and acoustic), and physically sample and analyze a diverse set of chemical and biological components. Many of the technologies associated with sensors are in a state of rapid evolution and will remain so for the foreseeable future. Moreover, many sensing functions and devices that are important to the Air force have counterparts in commercial, industrial, and medical applications. This combination of ubiquity, operational impact, technology leverage, and dual use potential makes the subject of sensors especially important to the themes of *New World Vistas*.

The Sensors Volume describes the future of sensors from the viewpoints of operational pull and technology push. Operational tasks that stress current sensors are described along with key enabling technologies. Seven illustrative sensor system concepts are then presented to indicate the importance of integration of multiple sensors. Finally, based on a survey of the overall sensor technology arena, nine high potential technology areas are described in some detail.

Dr. Jack L. Walker
Chair, Sensors Panel
15 December 1995

Panel Membership

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Dr. Gunter Stein
Dr. Barbara A. Wilson
Dr. Peter R. Worch

Dr. E. Glenn Gaustad
Dr. Darryl P. Greenwood
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Space Applications Volume Abstract

The application of space in future military operations will facilitate global presence, knowledge on demand, space control and power projection.

Successful integration of space with information based warfare capabilities will be critical to maintaining information dominance of the battle space and winning at information warfare. Key capabilities are space-based observation, space communications, and global positioning, mapping and time transfer.

The proliferation of commercial space systems gives our adversaries unprecedented access to militarily significant capabilities that will reduce the information advantage our forces presently enjoy.

The need to disrupt, deny and influence the enemy's perception of the battle space while assuring our use for information based warfare is essential, and thus space control takes on new significance in this environment.

In the future to support global presence it will become feasible to project force from space directly to the earth's surface or to airborne targets with kinetic or directed energy weapons.

All of this is possible with the continued improvement of space systems operations with reduced manpower at lower cost, design of spacecraft with modern low cost techniques, adaptation of innovative architectures incorporating distributed satellite systems and the development of affordable access to space.

Dr. Michael I. Yarymovych
Chair, Space Applications Panel
15 December 1995

Panel Membership

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Mr. Julian Caballero
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Mr. Samuel M. Tennant
Mr. David W. Thompson
VAdm Jerry O. Tuttle, USN (Ret)
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Mr. Keith K. Hazard
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Space Technology Volume Abstract

The Space Technology panel's recommendations for technology investments derive from a vision of the Air Force in space in the 21st century, in which the Air Force has achieved survivable, on demand, real time, global presence that is affordable. This vision represents a revolutionary increase in capabilities for the Air Force and is achievable with targeted Air Force technology investments and adaptation of commercial developments.

Several key technologies offer the possibility of a substantial increase in the exploitation of space by the Air Force, the potential impact of which is so great that the Air Force must invest now. These technologies are:

- High-energy-density chemical propellants to enable spacelift with high payload mass fractions—specific impulses of 1000 seconds or greater (in high-thrust systems) should be the goal of this effort
- Lightweight integrated structures combining reusable cryogenic storage, thermal protection, and self diagnostics to enable a *responsive* reusable launch capability
- High-temperature materials for engines and rugged thermal protection systems
- High performance maneuvering technologies such as electric propulsion (with thrusts greater than tens of Newtons at specific impulses of thousands of seconds at near 100% efficiency - the goal for electric propulsion) and tethers for momentum exchange
- Technologies for high power generation (greater than 100 kilowatts) such as nuclear power, laser power beaming, and electrodynamic tethers
- Technologies for clusters of cooperating Satellites (e.g., high-precision stationkeeping, autonomous satellite operations, and signal processing for sparse apertures)

Prof. Daniel E. Hastings
Chair, Space Technology Panel
15 December 1995

Panel Membership

Prof. Daniel E. Hastings, Chair
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Dr. Edward Euler
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Col Ron Sega
Dr. Babu Singaraju
Dr. Barbara A. Wilson

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Maj C. Lon Enloe
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Classified Volume Abstract

The classified volume report is a compilation of classified material (text and charts) that could not be discussed in this Summary Volume nor in any of the 12 unclassified panel report volumes. The panels that wrote material containing sections of classified material found in this volume and referenced in their volumes are: Munitions, Space Applications, Directed Energy, and Information Applications. A brief unclassified description of some of the topics found in this volume are provided below:

- **Munitions -** A concept of preventing enemy electronic operations using radio frequency (RF) attack cruise missiles; and a concept of using a self-protect missile for aircraft survivability. Over the past decade, electromagnetic technology has been sufficiently developed to consider practical development of weapons of this kind.
- **Space Applications** - An emphasis on space control capabilities, both offensive and defensive, are discussed as possible means in future warfare. These means could be applied to any element of the space system to include: the ground capabilities; the spacecraft links; the spacecraft itself; and the processing and distribution of the information. Also, a discussion of space tethers as a spacecraft survivability concept is provided.
- **Directed Energy** - Various concepts of directed energy weapon systems playing a role or as a means of future space control or supporting military missions are discussed.

- **Information Applications** - In the widely distributed global information system of the future, it will be difficult to determine sources of adversary information. This section discusses technologies and concepts for intelligence gathering and information attack in the commercially based, distributed global information system of 2025.

Ancillary Volume Abstract

In November 1994, the Secretary of the Air Force, Honorable Sheila E. Widnall and the Air Force Chief of Staff, General Ronald R. Fogleman, challenged the Air Force Scientific Advisory Board to "rekindle their inquisitive attitude" which had originated one half century before when Dr. Theodore von Kármán was tasked by General of the Army, Hap Arnold, to look to the future and make a report—a blueprint—on which to build an independent Air Force . As part of this current study, *New World Vistas*, Dr. Gene McCall, SAB Chairman, asked the members of the Board to take an individual shot at the future. The nature of forecasting in the Air Force has gone through many iterations. The first forecast was produced by only 31 of the nation's finest minds. The current forecast team is nearly five times that size. But times have changed.

Today, it is no longer possible to gather the majority of America's aeronautical scientists in one university auditorium. The surreal explosion of computer technology and the expansion of aeronautics into astronautics, and all of the disciplines which are related to advances in these areas, makes comprehensive individual reports a true impossibility. No longer can one scientist know all there is to know in one field of study.

But many scientists will tell you that, every once in a while, an individual brilliant thought triggers a breakthrough. This is the purpose behind these essays. Perhaps in reading these individual thoughts about the future, a moment of brilliance will result within you and trigger a breakthrough in your field . It may not happen this year or in ten years, but it might happen someday. Fifty years ago this kind of individual thought resulted in the creation of *Toward New Horizons*, the blueprint upon which was built the supremacy of today's Air Force.

This volume contains these essays and several interviews conducted by Mr. Jim Slade and Maj Dik Daso during the production of a one hour video program dedicated to the 50 year history of the USAF Scientific Advisory Board.